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direction of gravity, but not contrary to the direction in which that force is now working, which alone concerns us.

The whole matter hinges on the ability of a plane to resolve the gravitating force as it resolves other forces. In doing so it does a very wonderful thing. It makes of gravity a continuous motive power. It introduces a new idea into our conceptions of things, and makes it imperative that we rectify our notions of the gravitating force so as to admit these facts, which we have not hitherto recognized.

It dignifies the soaring birds into the position of favored creatures of nature. They inhabit a universe of their own. The horizon of their world is not the level of the sea, but the incline of their own wings, which they can change at will. Their gravitating force is either in a straight line from their bodies towards the center of the earth, or the moon, or the sun, or any of the stars of heaven, indifferently, as it suits them, to sleep on the breeze, to play at gymnastics high in air, to enact the rôle of the highway robber, or to serenely float from zone to zone.

I have now presented the case of the soaring birds to the extent of my ability. The task could have been better done by a specialist in analytic mechanics, as it is in this sphere that its significance lies. The whole matter is extremely peculiar. In consequence of the throng of preconceived ideas which tend to cast the obscurity of night over the whole case, the evidence upon which it rests, although axiomatic throughout, is difficult to see. The mechanism also seems devoid of organization, a simple plane is all there is of it, and still it has the power to change the horizon of the world to suit its own purposes. It would be unwise to suppose that a device capable of doing this was not competent to give to man what he has long coveted, the power to navigate the air.

Certainly we must entertain two standards of horizontal, one the level of the sea, and the other the incline of the wings of the soaring birds.

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## CAUSES OF FOREST ROTATION.

BY JOHN T. CAMPBELL.

**I**N a letter recently received from Dr. S. V. Clevenger, he mentioned a case coming under his own observation on the North Pacific railroad, in Minnesota, near Mille Lacs, where the railroad

company cut the pine timber off of their own alternate sections for railroad ties and other purposes. This pine forest was succeeded at once, to all appearances spontaneously, by oaks.

I have often heard North Carolinians say the same thing about old fields in that State, when abandoned as worn-out land, that some timber different from that which had been cut off when clearing the land at first, would spring up spontaneously, or appear to be spontaneous.

I can speak only for my own locality, not having observed any other. Here (West central Indiana) we have in many localities a prevailing species of timber, but no species that exist to the exclusion of all others, as is often the case with pine. But of our prevailing timber, or any other kind, sugar maple excepted, none seem to be reproducing their kind in their immediate vicinity. For reasons which will follow, I surmise that nearly all forest trees bear and shed leaves which are unfavorable to the sprouting and growing of their own seeds. The most notable instance I can now think of is the red cedar, introduced into this vicinity from the north and north-east about forty-five years ago for ornamental purposes. I don't remember at what age they began bearing seed, but I think as early as ten years, counting them to have been three years old from the seed when transplanted here. Until certain kinds of birds began to eat their seeds, they were not found growing wild in the forests. I do not know what birds eat the seed, but evidently all do not, else they would have been planted as soon as the parent trees bore seeds, which was not the case for fully fifteen years afterward. When these seeds pass through the craw and intestines of birds they are prepared to sprout when they come in contact with the ground of the proper degree of moisture. Nurserymen, when they gather them direct from the trees, are obliged to put them through some process of scalding before planting. The birds drop them promiscuously over the country, where they have been appearing within the past fifteen years numerously, and only rarely before about that time. They are a hardy tree, and bid fair to become one of the forest trees of the future in this part of Indiana. It is reasonable to presume that these seeds would be more abundantly dropped under and very near these parent trees than elsewhere, for quite probably the birds that nest in these trees eat their seeds. Yet no young cedars are ever seen to sprout and grow there.

The same is true (*i. e.*, not growing their young within the radius of their leaf-fall) of the white pine, firs and other evergreens transported here for ornamental purposes. Some of the older ones are twenty inches in diameter, and have borne seeds many years.

I have long observed that the seeds of forest trees shed upon the forest leaves, sugar maple excepted, cannot sprout. This is very specially the case with the American poplar seeds. Yet I often find in the woods clusters of young poplars, varying in age from one year to sixty and seventy years. Last year I found out how this comes about. If the seeds happen to fall on the bare ground of the right degree of moisture, they at once take root and grow. If about the time these seeds are falling there should be a hog in the woods and he should have an appetite for ground worms, he would thrust his strong snout through the leaves into the ground and cast up fresh earth in a very promiscuous manner, and every poplar (or other) seed that should happen to fall on that fresh ground would stand a good chance of growing. I saw young poplars just barely sprouted under the above circumstances, while at the same time other and brother seeds had fallen on the leaves near by, where they lay dead and as dry and crisp as smoking tobacco.

Sometimes squirrels, hares, ground squirrels (chipmunks) dig through the leaves into the ground for food which they find there, I presume, and these places give a chance for one or more seeds to grow, and the hoofs of heavy bullocks (and in times past the elk and buffalo) have made deep tracks through the leaves into the ground, which would give a like chance, whilst the coating of leaves would prevent the growth of all the rest. The hogs were brought here at the very earliest time of settlement, turned loose in the woods, where they multiplied rapidly, becoming wild, ferocious and more dangerous to man than bears, wolves or panthers. Many of these clusters of poplars correspond in age to this time.

In Rockville, Indiana, where I reside, the river-bottom soft maple is very generally planted for a street shade-tree, mainly because of its rapid growth. Many of these are ten to twenty inches in diameter at the butt, and have been bearing seeds for years. The seeds of this tree must find favorable growing conditions as soon as they fall or they are lost, for one day's baking in the hot sun kills them. They must have a steady moisture

with warm but not hot sunshine. The trees bore a bountiful crop of seed last May, and of the first that matured and fell, I tried to sprout about a dozen by placing them in good ground and watering every day for several days. But as I could not give them all my time, they dried up between waterings and died. After these had died, there came a threatening, blustering storm one Sunday evening about sundown, which shook off the remaining soft maple seeds. They were so abundant that they gave the streets a buff color where they fell. The wind was followed by a light, steady rain, which continued several days, alternating with sunshine. This was favorable to sprouting these seeds, and they came up all over the streets, yards, and gardens as thick as weeds in a neglected field, a thing that never happened before in the twenty-two years I have resided in the place. Those in the street the cows ate up; those in the gardens were weeded out, and those growing elsewhere were killed by the following summer drought. On the south end of my garden, where a cellar drain terminates, the proper moisture was maintained through the drought, and there stands a thick cluster of them, the only survivors, so far as I know, of the millions that sprang up last May. After these trees are three years old they can be successfully transplanted into any kind of soil we have here, and seem as hardy as any dry-ground tree; but during their infancy the conditions *must* be as before stated or they die. So I think it is clear that this tree will never be self-planting, except along the low, moist bottom of the streams where we find it native.

The hard sugar maple does plant its own seeds within the radius of its own leaf-fall. In 1884 there developed a local rain in the south-east quarter of this (Parke) county which continued showery for several days, alternating with sunshine, just as the sugar maple seeds were falling. The result was as in the case of the soft maples last May; all the seeds sprouted. As this favorable condition did not happen when the other trees were shedding their seeds, the result in that part of the county is, that the sugar maples are a hundred to one of all the other young trees combined, and the deep snow and cold winter that followed, making a hard crust on the snow, prevented the sheep, cattle and rabbits (hares) from browsing them down, though it starved thousands of rabbits, as their bones found in hollow logs and trees abundantly attest; but it saved the young sugar maples till they are

now large enough to be safe from every enemy except man. If he were out of the way for 150 years about all the present forest trees will have lived out their time, and these young sugar maples would be almost the only trees of the forest in the area where a rain happened to fall with the seed. In the other three-quarters of the county that state of things would not exist, for there only the lucky seed that fell where a hog had rooted or a bull had trodden has made a tree, and this luck was as favorable to other seeds as to the sugar maple. These maple seeds send rootlets right down through the coating of leaves into the ground, and I have seen, over an area of many acres at a time, a maple sprout for every four inches square, or nine to the square foot, none seeming to have missed sprouting. In replanting the ground where the present forest has been cut away, the sugar maple makes the least show of all the forest trees. As an infant it seems to thrive best in the shade of older trees.

How the oak can take the place of pine where there are no oaks in the vicinity to bear acorns, I am not sure, but it is easier and more rational to believe that there is some natural agency for transporting the seed of the apparently spontaneous new tree, than to believe it to be really spontaneous, whether we understand the transporting agency or not.

One of the most industrious and persistent seed-transporting agencies I know of is that ubiquitous, energetic, rollicking, meddlesome busybody, the crow. Did you ever take a young crow and raise it as a pet? Please do so once and you will have more information about crows than I could give you in an entire number of the *NATURALIST*. They become very tame, and after they are able to fly it seems to be the delight and work of their lives to pick up and carry from place to place any and every article which is not too heavy for them. After a pet crow has had a little practice he is as expert at tricks of legerdemain as a showman. He will steal a spool of thread, a thimble, a pair of scissors, a paper of pins, or what not? right before your eyes, and as he flies away will tuck it so adroitly up under his tail feathers that you can't see it. He makes a deceptive grab as he starts to fly, by taking a few steps as if to give himself a little momentum to start his flight, and one of these steps he will plant square on the article he intends to steal, when his claws close round it and off he goes. Perchance he will alight only a few yards distant

on the ground beside a chip, which chip, as he alights, he will so quickly and adroitly turn over with the other foot as to cover out of sight the article he has taken. He will then take a few steps about the chip with his toes all properly radiating, purposely to show you that he does not hold the missing article in his claw. Unless you are acquainted with his tricks you would concede that he had not taken your thimble, so adroitly is the trick performed. Then he is ready for some new mischief. Off he goes to the chicken-yard where a hen and her chicks are scratching for bugs. He alights plump into their midst. The little chicks scream and scamper for shelter. The old hen, with her feathers all awry, dashes at him as if she would tear him into strings, but just as she gets in striking distance the crow opens his mouth and caws loudly right into her face. She stops abruptly, hesitates and slowly backs off. Then comes the cock of the yard, like a charge of cavalry, to drive the intruder from his premises ; but as he too gets in striking distance, the crow opens his mouth about three inches wide and caws so loud, right into the cock's face, that he can be heard a quarter of a mile. The cock too stops suddenly, and his look of surprise and amazement is most amusing. His wrothy feathers gradually smooth down and he takes a few steps cautiously backward, then whirls and runs back under the rose-bush and there tells the hens how the crow acted, like Irving's Knickerbocker soldiers who were sent up the Hudson to capture a fort, and who had nose, thumb and fingers all wiggled at them at once over the wall by the garrison, which was such a strange and unexpected proceeding that they hastened back to headquarters to report what had taken place.

I had a pet crow two years ago that cut so many tricks in his way that a neighbor shot him one morning. Afterward, in cleaning the leaves out of my eave troughs, various of our own and our neighbors' articles were found in the troughs and on the roof.

The crow in his wild state is all the time busy at some such work as I have described. I cannot discover that he has any design in this busy, meddlesome mischief. If there is design in his work it is back of the crow in the Great Superintendent of nature's processes. I have seen crows gather by hundreds and have a regular pow-wow, a mass convention where they seemed to discuss measures and appoint officers. I have heard their cawing

more than a mile distant. At length they get through, by finishing their work or tiring of it, and disperse. As they start to fly away many, if not all, will drop something. I have found these to be acorns, walnuts, hickory-nuts, buckeyes, sycamore-balls, sticks, egg-shells, pebbles, &c. As a crow leaves an oak he will pluck an acorn which he may carry five miles and light on a beech tree, where something else will attract his attention, when he will drop the acorn and may be pluck a pod of beech nuts and fly away somewhere else.

The squirrel is also a nut-transporting agent. The hog will eat his nut where he finds it, but the squirrel must find some suitable place to eat his nut, like some fastidious boarders I have known, who would not and could not eat if they failed to get their own conspicuous place at table. The squirrel will select his nut, take it in his mouth, skip along a few yards, pause a moment, then a few more skips and pause, preferring a fence or fallen tree to the ground for his roadway. He will sometimes carry his nut several hundred yards, not to his home, but to some conspicuous tall fence-stake or dead projecting limb of a tree, on which he sits on his haunches, his tail curled over his back, and in this striking attitude he complacently gnaws through the shell of his nut to get the kernel. It will sometimes happen that just as he is ready to begin on his nut a hawk will swoop down after him, and His Complacency is glad to drop his nut and flit down to the under side of the limb for protection. This nut may fall on good ground and make a future great forest tree. He will be chased by a dog, fox or hawk sometimes while on his way to his eating place, and involuntarily plant an oak, a walnut or hickory. The partition fences across our cleared farms and stumps out in the fields have many such planting of oak, walnut and hickory, far from the trees that bore the nuts, which I attribute to the crow or the squirrel.

I know a place about four miles south-west of here, where a low place in a field was too wet to be plowed, and has grown up full of young bur oaks, but there is no parent tree anywhere near, not near enough even for high winds to carry such acorns. Such acorns sprout only in wet ground. I think this grove of bur oaks is the result of a frolic of the crows. They had a previous frolic on a bur oak, and in leaving it for this place, each carried an acorn, as is their habit,